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CHEMISTRY.—*Crystals of barium disilicate in optical glass.* N. L. BOWEN, Geophysical Laboratory. (Communicated by J. C. Hostetter.)

In optical glass of the variety known as "barium crown," and especially in those types rich in barium, there frequently form in the melting furnace numerous six-sided crystal plates

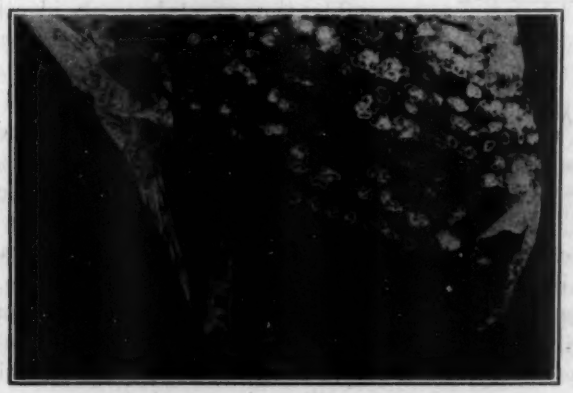

FIG. 1. Fragment of barium crown glass showing crystals of $BaSi_2O_5$ with "frayed" edges. (Natural size.)

upwards of 3 mm. in diameter. These crystals are colorless and transparent in their central portions but are surrounded by white opaque rims that render them very conspicuous (see photograph, fig. 1). A piece of glass containing these crystals, with their

marked symmetry of outline and their common arrangement with greater dimensions parallel to flow lines in the glass, constitutes a specimen of much beauty and perhaps of some interest to the mineralogist, though nothing could be more ruinous to the glass for optical purposes than this incipient crystallization. Even glass which comes from the melting furnace free from this defect may devitrify during subsequent heat treatment with formation of crystals of the same nature, though in this case of much smaller dimensions. One step in an investigation designed to discover the best conditions for avoiding the formation of these crystals involved a determination of their nature.

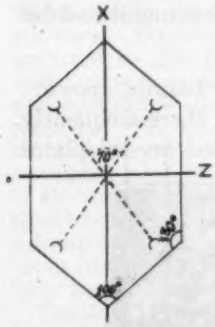

FIG. 2. $BaSi_2O_5$ showing optical orientation.

Under the microscope the larger crystal plates that form in the melting furnace are found to be about 0.03 mm. thick in the transparent central portion, which is a single crystalline unit of uniform orientation. Around the edges of the larger crystal, however, innumerable tiny crystals, each identical in nature and in habit with the larger crystal, have sprouted out in all directions. These tiny crystals with their interstitial glass, giving diffusion of light, constitute the white opaque rims of the larger crystals. The arrangement recalls the feldspar microlites with fibrous edges sometimes seen in rocks.[1]

The crystal plates have the shape of an elongated hexagon as shown in figure 2, and are about 3 mm. long and 2 mm. wide. The terminal angles as measured under the microscope are approximately 100° and the lateral angles 130°. As shown by their symmetry, taken together with their optical properties, the crystals are orthorhombic. There is a good cleavage parallel to the elongation. The elongation is always negative. The plane of the optic axes is parallel to the platy development and the optical character negative with $2V = 70°$ approximately. The refractive indices are: $\gamma = 1.613$ and $\alpha = 1.595$, as measured in immersion liquids under the microscope.

[1] Figured by J. P. Iddings in Rock Minerals, p. 215, 1911.

The optical properties correspond with those of no crystals hitherto described. In casting about for a possible composition for the crystals the orthorhombic symmetry of $K_2Si_2O_5$ was recalled together with the general tendency towards isomorphism of potassium and barium compounds and it was thought possible that the crystals might be $BaSi_2O_5$. Accordingly a mixture of that composition was made up and melted in a platinum crucible and this was found to give on cooling a homogeneous crystalline mass having optical and crystallographic properties identical with those exhibited by the crystals in the glass. The refractive indices were determined on this pure material, on which they can be determined with greater accuracy than on the very thin crystals embedded in glass. They are as follows: $\gamma = 1.617$, $\alpha = 1.598$.

It is probable that the slightly lower values given for the crystals in the glass represent a real difference and that when formed from the glass they take a small amount of alkaline disilicate into solid solution, but this cannot be definitely decided without measurements on larger crystals that will permit of greater accuracy. The very minute crystals formed by devitrification of the glass at low temperatures appear to have indices that are even somewhat lower still, suggesting that they have a larger amount of alkaline disilicate in solid solution. The probability of solid solution between barium disilicate and potassium disilicate is very great, for they show a striking degree of isomorphism, the corresponding angles of potassium disilicate being, within the limits of error of measurement under the microscope, exactly the same as those here found for barium disilicate.[2] In subsequent work a detailed study of solid solution between these compounds will be made.

Barium disilicate appears not to have been prepared and studied before and this note has been written to place its properties on record. To make it more complete the melting point has been determined. It was found to melt congruently at 1426°C., as determined with a platinum-rhodium thermo-element and potentiometer system. The only reference in the literature to

[2] See crystals figured by Fenner in a paper by G. W. Morey (*New crystalline silicates of potassium and sodium.* Journ. Amer. Chem. Soc. **33**: 228, fig. 4. 1914.)

$BaO.2SiO_2$ is given in Gmelin-Kraut, where it is stated that a mixture of that composition melts to a clear glass.[3] This observation was confirmed and the refractive index of the glass was measured and found to be 1.606.

J. W. French describes a crystal enclosed in "optical flint glass" which is hexagonal and beautifully regular and shows "stream lines" about its edges.[4] From the general description I would consider it possible that his crystal was identical with those of barium disilicate here described were it not for the fact that he noted no colors in polarized light. This may, however, have been due to the extreme thinness of his crystals. It is true the glass is called a flint glass which, in speaking of optical glass, means a lead glass; but it is also stated that the source of the glass and its composition are unknown.

I am indebted to Mr. L. H. Adams for the photograph of the glass specimen, to Mr. Olaf Andersen for a survey of the literature in search of previous information on barium disilicate, and to Mr. G. W. Morey for calling to my attention the article by French.

GEOLOGY.—*Correlation of the Tertiary geologic formations of the southeastern United States, Central America, and the West Indies.*[1] THOMAS WAYLAND VAUGHAN, Geological Survey.

The present paper contains tabular statements of the results derived from prolonged investigations of the stratigraphic equivalence of the Tertiary geologic formations in the South Atlantic and Gulf Coastal Plain of the United States, Mexico, Central America, and the West Indies. The tables are excerpted from two larger papers I now have in course of publication, referred to in the foot-note below,[2] but as the two papers men-

[3] GMELIN-KRAUT, Handbuch der Anorganischen Chemie, **3**[1]: 237–238.

[4] Trans. Optical Soc. **16**: 224. 1916.

[1] Published by permission of the Director of the U. S. Geological Survey.

[2] VAUGHAN, T. W., *The biologic character and geologic correlation of the sedimentary formation of Panama in their relation to the geologic history of Central America and the West Indies.* U. S. Nat. Mus. Bull. 103 (in press); *Cenozoic history of Central America and the West Indies.* Geol. Soc. Amer. Bull., vol. 29 (ready for press).

tioned are not likely to be distributed within less than twelve months and as there is considerable demand among geologists for the stratigraphic results contained in them, it is desirable at least to publish promptly the tabular summaries.

Tables such as those here given are necessarily based on the work of many men, and I wish to express my indebtedness to E. W. Berry, J. E. Brantly, C. W. Cooke, J. A. Cushman, W. H. Dall, Alexander Deussen, E. T. Dumble, E. N. Lowe, W. C. Mansfield, G. C. Matson, G. S. Rogers, E. H. Sellards, E. W. Shaw, H. K. Shearer, and L. W. Stephenson, who have contributed to the literature on the Tertiary formations of the southeastern and southern United States during the past six years. I have also had the benefit of the unpublished results of F. Canu and R. S. Bassler on the Tertiary Bryozoa of the Coastal Plain of the United States and of Miss Julia Gardner on the Mollusca of the upper Miocene of Virginia and North Carolina and of the lower Miocene (the Alum Bluff formation and its members) of Florida. More specific referrences to the contributions of these investigators will not be made in this place.

Recently the Director of the U. S. Geological Survey, in fulfilment of a cooperative agreement between the Geological Survey, the Canal Commission, and the Smithsonian Institution, transmitted to the Secretary of the Smithsonian Institution the manuscript and illustrations for a volume entitled *Contributions to the Geology and Paleontology of the Canal Zone, Panama, and Geologically Related Areas in Central America and the West Indies. Prepared under the direction of T. W. Vaughan.* This volume contains the following papers: Preface, by T. W. VAUGHAN; On Some Fossil and Recent Lithonamnicae of the Panama Canal Zone, by M. A. HOWE; The Fossil Higher Plants from the Canal Zone, by E. W. BERRY; The Smaller Fossil Foraminifera of the Panama Canal Zone, by J. A. CUSHMAN; The Larger Fossil Foraminifera of the Panama Canal, by J. A. CUSHMAN; Fossil Echini of the Panama Canal Zone and Costa Rica, by R. T. JACKSON; Fossil Bryozoa from the Canal Zone and Costa Rica, by F. CANU and R. S. BASSLER; Crustacea Decapoda from the Panamanian Region, by M. J. RATHBUN; Cirripedia from the Panama Canal

Zone, by H. A. PILSBRY; Fossil Corals from Central America, Cuba, and Porto Rico, with an Account of the American Tertiary, Pleistocene, and Recent Coral Reefs, by T. W. VAUGHAN; The Sedimentary Formations of the Panama Canal Zone with especial reference to the Stratigraphic Relations of the Fossiliferous Beds, by D. F. MACDONALD; The Biologic Character and Geologic Correlation of the Sedimentary Formations of Panama, in their relation to the Geologic History of Central America and the West Indies, by T. W. VAUGHAN. These memoirs are in press as Bulletin 103 of the U. S. National Museum.

A set of memoirs on the Lesser Antilles and Cuba, similar to that on the Canal Zone, is almost complete, and will be submitted to the Carnegie Institution of Washington for publication. The stratigraphic results procured from the West Indian investigations have been utilized in making geologic correlations.

CORRELATION OF THE TERTIARY FORMATION OF THE SOUTH ATLANTIC AND EASTERN GULF COASTAL PLAIN

Table 1 indicates the present status of the correlation of these formations, and although it may have to be modified to accord with the results of additional investigations, there seems to be every reason to believe that subsequent changes will be only in matters of minor refinement. However, I wish to say that in my opinion four paleontologic zones will be discriminated and defined in the Chattahoochee formation, and that the collections on which to base these subdivisions have already been made and in large part described, but I will not now discuss those details. I confidently expect the Ocala limestone also to be subdivided into two or more zones, for the genus *Orthophragmina* so abundantly represented in the lower part of the formation appears to be absent in the upper beds.

CORRELATION OF THE TERTIARY SEDIMENTARY FORMATIONS OF PANAMA AND THE WEST INDIES

Three new stratigraphic terms introduced in table 2 need to be briefly defined in this place. More comprehensive definitions are

given in my paper on the fossil corals from Central America, Cuba, and Porto Rico.

St. Bartholomew limestone. This formation is of upper Eocene age and is paleontologically characterized by species of *Orthophragmina*, one of which is of stellate form, similar to those recently described by Cushman[3] from the Ocala limestone of Georgia and Florida; by about 30 species of corals, among which the genera *Stylophora*, *Astrocoenia*, *Antilloseris*, *Physoseris*, and *Actinacis* are conspicuous; by many echinoids, which were described by Cotteau; and by some Mollusca and Brachipoda described by C. W. Cooke in a manuscript now awaiting publication. The formation is typically exposed along the shore of St. Bartholomew northwest of St. Jean Bay for a distance of about one and a half miles. The rock is a hard bluish limestone, interbedded at its base with volcanic tuffs and water-worn volcanic fragments.

Anguilla formation. This formation is uppermost Oligocene, if the Aquitanian of Europe is correctly referred to the Oligocene. In the opinion of some paleontologists it would be classified as earliest Miocene. It is paleontologically characterized by certain Foraminifera, described by J. A. Cushman in a report not yet published; by numerous species of corals, among which are the genera *Stylophora*, *Stylocoenia*, *Antillia*, *Orbicella*, *Siderastrea*, and *Goniopora;* by echinoids described by Guppy or by Cotteau, among which are *Echinolampas semiorbis* Guppy, *E. lycopersicus* Cotteau, and *Agasizzia clevei* Cotteau; and by a number of species of Mollusca, described in manuscript by C. W. Cooke. The Mollusca include *Amusium lyonii* Gabb and *Orthaulax pugnax* (Heilprin). I obtained no specimens of *Lepidocyclina* in Anguilla. The type exposure is along the southeast and south shore of Crocus Bay. The material consists of calcareous clay, argillaceous limestone, and more or less pure limestone. The formation unconformably overlies basic igneous rock.

[3] CUSHMAN, J. A., *Orbitoid foraminifera of the genus* Orthophragmina *from Georgia and Florida.* U. S. Geol. Survey Prof. Paper 103: 115–124, pls. 40–44. Dec. 12, 1917.

A Provisional Correlation Table of the Tertiary Geologic Formations of

Age of deposits		North Carolina (South of Hatteras axis)	South Carolina (Santee drainage)	South Carolina and Georgia (Savannah drainage)	Georgia (Chattahoochee drainage)
Pliocene		Waccamaw marl	Waccamaw marl	(Not recognized)	
Miocene	upper	Duplin marl Unconformity	Duplin marl Unconformity Edisto marl	Duplin marl Unconformity Marks Head marl	
	middle	(Absent)		Unconformity	
	lower			Alum Bluff formation	Alum Bluff formation
Oligocene	upper			Chattahoochee formation	Chattahoochee formation
	middle				Unconformity
	lower				Vicksburg formation
Eocene	upper	Castle Hayne limestone Trent marl	Cooper marl / Barnwell formation	Barnwell formation (with Twiggs clay member)	Ocala limestone
	middle		McBean formation	McBean formation	McBean formation
	lower		Congaree shales of Sloan Williamsburg formation	(Probably overlapped)	Wilcox formation
			Black Mingo formation	(Probably overlapped)	Midway formation

FLORIDA	ALABAMA	MISSISSIPPI	LOUISIANA
Caloosahatchee marl, Nashua marl, Alachua clay, and Bone Valley gravel (largely contemporaneous) / Citronelle formation	Citronelle formation	Citronelle formation	Citronelle formation
Jacksonville formation / Choctawhatchee marl	Pascagoula clay	Pascagoula clay	Pascagoula clay
(Absent) / (Absent)			
— Unconformity —			
Alum Bluff formation: Shoal River marl member; Oak Grove sand member; Chipola marl member	Alum Bluff formation / Hattiesburg clay	Hattiesburg clay	Hattiesburg clay
Tampa formation / Chattahoochee formation	Chattahoochee formation / Catahoula sandstone	Catahoula sandstone	Catahoula sandstone
Vicksburg group: Marianna limestone (western Florida)	Vicksburg group: Marianna limestone (with Glendon limestone member); Red Bluff clay	Vicksburg group: Byram calc. marl; Marianna limestone (with Glendon limestone and Mint Spring calc. marl members); Red Bluff clay	Vicksburg limestone
Ocala limestone	Ocala limestone / Jackson formation	Jackson formation (with Yazoo clay member and Moodys calc. marl member)	Jackson formation
(Buried)	Claiborne group: Gosport sand; Lisbon formation; Tallahatta buhrstone	Claiborne group: Yegua formation; Lisbon formation; Tallahatta buhrstone	Claiborne group: Yegua formation; St. Maurice formation
(Buried)	Wilcox group: Hatchetigbee formation, Bashi formation, Tuscahoma formation, Nanafalia formation	Wilcox group: Grenada formation, Holly Springs sand, Ackerman formation	Wilcox formation
(Buried)	Midway group: Naheola formation, Sucarnochee clay; Clayton limestone	Midway group: Tippah sandstone of Lowe, Porters Creek clay; Clayton limestone absent or replaced by sand	Midway formation

TABLE

A PROVISIONAL CORRELATION TABLE OF THE TERTIARY

AMERICAN TIME SUBDIVISIONS		PANAMA	JAMAICA	OTHER ANTILLES
Pliocene		Toro limestone	Manchioneal formation Kingston formation	Pliocene of Guantanamo, Cuba
Miocene	upper			
	middle	Gatun formation		La Cruz marl (Cuba) / Upper horizon in Martinique / Upper horizon in Santo Domingo
	lower		Bowden marl	Marl at Barnoa, Cuba / Lower horizon in Martinique / Zones G, H, and I in Santo Domingo (of Miss C. J. Maury)
Oligocene	upper	Emperador limestone Culebra formation: Upper part of Culebra		Anguilla formation (Anguilla), and beds at many localities in Cuba
	middle	Culebra formation: Lower part of Culebra and limestone at Tonosi		Coral reef at Guantanamo, Cuba / Antigua formation (Antigua) / Pepino formation (Porto Rico) / Lower horizon in Santo Domingo
	lower	Limestone with *Orthophragmina*, on Haut Chagres[a] and limestone at David (contemporaneous)[b] / Bohio congl.[a]	Montpelier white limestone	
Eocene	upper		Cambridge formation Richmond formation	St. Bartholomew limestone (St. Bartholomew) Extensively distributed in Cuba
	middle	Eocene of Tonosi		
	lower			

[a] Reported by H. Douvillé and referred to "Stampien inférieur" = Vicksburgian = Lattorfian.

[b] May be upper Eocene instead of lower Oligocene.

MARINE SEDIMENTARY FORMATIONS OF PANAMA

MEXICO AND CENTRAL AMERICA	SOUTHEASTERN UNITED STATES	EUROPEAN TIME SUBDIVISIONS
Pliocene of Yucatan and Limon, Costa Rica	Waccamaw marl, Nashua marl, and Caloosahatchee marl (nearly contemporaneous)	Sicilian Astian Plaisancian
	Yorktown formation, Duplin marl, and Choctawhatchee marl (nearly contemporaneous)	Pontian Sarmatian
	St. Marys formation Choptank formation	Tortonian
	Calvert formation; Marks Head marl	
		Helvetian
Gatun formation (Costa Rica); Pacific Coast of Nicaragua; Exposures on Isthmus of Tehuantepec	Alum Bluff formation: Shoal River marl member; Oak Grove sand member; Chipola marl member	Burdigalian
San Rafael formation	Chattahoochee formation; Tampa formation	Aquitanian Chattian
		Rupelian
Manzanilla[b], Costa Rica, and deposits with Pecten aff: *P. poulsoni* and large discoid orbitoids, Mexico	Vicksburg group: Byram calcareous marl; Marianna limestone; Red Bluff clay	Lattorfian (Sannoisian)
Brito formation of Nicaragua (typical Brito); Frio clay Fayette ss.	Jackson formation; Ocala limestone	Ludian (Priabonian) Bartonian
Claiborne group; Wilcox formation; Midway formation; Near the Texas border	Claiborne group: Gosport sand; Lisbon formation; Tallahatta buhrstone	Auversian Lutetian
	Wilcox group: Hatchetigbee formation; Bashi formation; Tuscahoma formation; Nanafalia formation	Ypresian[d] Sparnacian[d]
	Midway group[c]: Naheola formation; Sucarnochee clay; Clayton limestone	Thanetian[d] Montian[d]

[c] May belong stratigraphically somewhat higher.
[d] Correlation proposed by E. W. Berry.

La Cruz marl. This marl is of midde Miocene age, as it appears to be slightly higher stratigraphically than the Burdigalian Bowden marl of Jamaica. The fossils obtained in it are described in my paper on the fossil corals of Central America, Cuba, and Porto Rico, and in unpublished manuscripts by J. A. Cushman and C. W. Cooke. Among the corals are the genera *Stylophora, Orbicella, Solenastrea, Thysanus, Siderastrea, Goniopora,* and *Porites. Solenastrea, Siderastrea,* and *Porites* contain species that I have been unable to distinguish from living West Indian species; but the genera *Stylophora, Thysanus,* and *Goniopora* are extinct in the Atlantic Ocean. The type exposure is along the railroad leading east from La Cruz, which is on the east side of Santiago Bay. The formation is well exhibited in the bluffs along the east side of the Bay north of the Morro. The material is a yellowish, very calcareous marl, or an argillaceous limestone, which is as a rule well bedded.

Only one point on the correlation table appears to need special comment, that is whether the limestone containing *Orthophragmina* on Haut Chagres and at David, Panama, should be referred to the uppermost Eocene or to the basal Oligocene. It has been stated above that the Ocala limestone contains large stellate species of *Orthophragmina,* and that I collected a similar species in St. Bartholomew. Of the Eocene age of these deposits, of the typical Brito formation in Nicaragua, and of certain limestones containing *Orthophragmina* in Cuba there seems to be no reasonable doubt. But, according to Douvillé, the small stellate *Orthophragmina* (subgenus *Asterodiscus*) ranges upward into the lower Oligocene. The association of *Asterodiscus,* and small, even non-stellate, species of *Orthophragmina,* with species of *Lepidocyclina* that at some localities are associated with a coral fauna of middle Oligocene affinities has inclined me to the opinion that certain peculiar species of *Orthophragmina* occur in deposits of early Oligocene age. Dr. Cushman, however, is disposed to regard the beds in which these species of *Orthophragmina* were found as of Eocene age. At present the evidence is not decisive, and additional studies are needed.

CRYSTALLOGRAPHY.—*Certain relations between crystalline form, chemical constitution, and optical properties in organic compounds,—I.* EDGAR T. WHERRY, Bureau of Chemistry.

That definite relations can be traced between the refractive indices and chemical constitution of substances has long been recognized. Most work has been done with organic liquids, and it has been found that each element possesses a characteristic refractivity, that the sum of the refractivities of the constituents, modified by their manner of combination, is equal to the molecular refractivity of the compound, and that from this in turn the refractive index can be derived.[1] Data for crystalline inorganic salts have been collected[2] and the relations shown to be similar; in systems other than the cubic (isometric) the mean refractive indices are usually employed. There is of course every reason to expect that the mean indices of crystalline organic compounds could be applied in like manner;[3] but it seemed desirable to inquire into the possibility of correlating the several indices of a given substance with its crystal structure instead of concealing in mean indices whatever relations may exist[4].

The refractive indices of substances may be connected with other properties by various formulas, of which the Lorentz-Lorenz expression, which may be used in the form $\frac{n^2 - 1}{n^2 + 2} = \frac{M \times \rho}{W}$, is the most satisfactory. For short the left hand term may be referred to as the "refraction," and denoted by the letter R. If the refractive indices in different directions in a single anisotropic substance be substituted for n, directional values of R will be obtained; these may be called R_a, R_b, and R_c, the first two of course being identical in uniaxial crystals.

[1] An excellent summary of this work has been prepared by Eisenlohr (Spektrochemie Organischer Verbindungen. Leipzig, 1912).

[2] Especially by Pope (Journ. Chem. Soc. **69**: 1530. 1896).

[3] The refractivities of a few crystalline organic compounds have been calculated by Taubert (Zeits. Kryst. Min. **44**: 313. 1910).

[4] The theoretical relations between the refractivities shown in the different directions in anisotropic substances and the electrical interaction of the atoms have recently been discussed by Silberstein (Phil. Mag. **33**: 92. 1917).

The atomic weight W being always, and the refractivity M usually the same throughout, the several values of R must be proportional to those of the density ρ, or factors corresponding to it, in the several directions. The ratio of the R's, which may be termed the "refraction ratio," should therefore give some information as to the structure of the substance.

Because of the existence of dispersion of double refraction or change in double refraction with wave length of light, the refraction ratio is not constant throughout the spectrum; but the following list of the approximate dispersions of a few typical substances, obtained mostly by extrapolation from recorded data, indicates that the effect of this phenomenon is ordinarily negligible, the variation in the ratio rarely exceeding the probable error of the data, 3 units in the third decimal place, over practically the whole visible spectrum. The relation will not hold, of course, in the ultra-violet, where these substances show absorption bands; but this does not affect the conclusions reached in this paper, for the atoms themselves are anisotropic for these short wave lengths.

TABLE I

APPROXIMATE DISPERSIONS OF DOUBLE REFRACTION OF SELECTED ORGANIC SUBSTANCES

UNIAXIAL	ω		ϵ		DOUBLE REFRACTION		REFRACTION RATIO	
Wave lengths	400	700	400	700	400	700	400	700
i-Erythrite	1.558	1.541	1.535	1.517	0.023	0.024	1.036:1	1.039:1
Guanidine carbonate	1.514	1.492	1.505	1.482	0.009	0.010	1.015:1	1.018:1
Urea[a]	1.504	1.480	1.625	1.597	0.121	0.117	0.837:1	0.834:1
BIAXIAL	α		γ		MAXIMUM DOUBLE REFRACTION		EXTREME REFRACTION RATIO	
Calcium formate	1.526	1.507	1.599	1.573	0.073	0.066	0.899:1	0.904:1
Cane sugar	1.551	1.537	1.582	1.569	0.031	0.032	0.956:1	0.954:1
Oxalic acid (anhyd.)[a]	1.465	1.440	1.650	1.620	0.185	0.180	0.758:1	0.750:1

[a] Extrapolated from new measurements by the writer, made by the immersion method.

The studies of crystals by X-rays which have been carried on in recent years have shown that it is possible to regard the atoms as lying in definite layers; in simple substances planes pass through

the centers of gravity of the atoms in these layers, while in more complex ones, the centers of gravity may be alternately slightly to one side or the other of planes.[5] The spacings between the planes prove to be more or less connected with the crystallographic axial ratios and other properties of the substances. The less the spacing of the atomic planes in any direction in an anisotropic substance, the greater should be the refraction in that direction. In fact, if the layers in the different directions are all close-packed, the difference in spacing may be the only cause of anisotropism, and the factor ρ will then be inversely proportional to the spacing d. It therefore appears probable that an exact inverse relation may exist in some cases between the refraction ratio and the crystallographic axial ratio of a substance.

Crystallographic axial ratios (which will be referred to hereafter simply as "axial ratios") are usually stated to the fourth decimal place. A variation of one minute in an angle, however, produces on the average a change of one unit in the third place, and crystals are rarely perfect enough for measurements to agree more closely than $\pm$ 5′. The fourth decimal is therefore usually entirely fictitious, and even the third often of doubtful significance. Refractive indices also are often stated to the fourth place, although the results of different observers usually differ one or two units in the third place. The refraction ratios are, accordingly, likewise obtainable with a certainty of but two or three units in the third place. In general, therefore, inverse agreement between the two ratios to one unit in the second place may be regarded as complete.

Furthermore it can not be assumed that the standard axial ratio is a definite thing. Crystallographers are obliged in general to choose one out of several possible forms as the unit, and to take the axial ratio as inversely proportional to the intercepts of that form on the axes. The criteria for selecting unit forms are limited in number, comprising prominence, presence of cleavage, and the yielding of simple symbols to the other forms present by the derived ratio. The Fedorov rule, that substances

[5] The latter arrangement appears, for instance, in the Bragg diagram of calcite (X-rays and Crystal Structure, p. 117).

with tabular habit and basal cleavage are likely to have a positive axial ratio (c greater than a) and those with prismatic habit and cleavage a negative one (c less than a) is also useful. All these features are, however, likely to be connected only with the larger atoms, and the presence of layers of smaller ones to be shown only by the appearance of minor forms, or even not to have any external expression at all. But as all the layers combine in the production of refractive effects, it is essential, before any comparison can be made, that the true axial ratio, based on all the atomic planes, be ascertained.

In the few anisotropic inorganic substances thus far studied by means of X-rays the standard axial ratios appear in fact to be produced only by certain of the larger atoms, smaller ones, such as oxygen, failing to find expression in them. But it seems likely that in organic compounds, where the relative sizes of the atoms do not differ so markedly, all might share in the location of the prominent forms, and the true axial ratio be identical with the standard one. This class of substances has therefore been investigated first, their refraction ratios and axial ratios being compared in order to ascertain whether inverse relations really exist; later papers will take up inorganic compounds. And at the start only those that crystallize in the tetragonal system will be considered, since its geometrical relations are the simplest, and will therefore form a good foundation upon which to base future studies in other systems.

Exact inverse relations can of course not be expected to hold in all cases. For instance, if the atoms in a layer are alternately considerably above and below the central plane, yet not far enough to become close-packed into new layers, the effect of the spacing on the refraction will be modified. Variations of several units in the second decimal place might be attributable to this cause. Further, if any of the constituent atoms are themselves anisotropic, which is probably the case with those giving rise to intense colors, as well as with those present in asymmetrical combination or position, the value of the refractivity, M, in the formula will vary with the direction, and even the first decimal place of the refraction ratio may be affected. While these

sources of variation render the method of study here proposed of little value in connection with the more complex compounds, it seems likely to be useful for simple ones.

Certain features of the tetragonal system may now be briefly reviewed. The classes it includes, with their symmetry and typical representatives, are listed in table 2.

TABLE 2

TETRAGONAL SYSTEM

CLASS			SYMMETRY			ORGANIC REPRESENTATIVE
	Standard name	Common name	Planes	Axes	Center	
1	Ditetragonal-bipyramidal..	Normal	4 vert. 1 hor.	1-4, 4-2	1	Mellite
2	Ditetragonal-pyramidal....	Hemimorphic	4 vert.	1-4	0	Pentaerythrite
3	Tetragonal-bipyramidal....	Pyramidal	1 hor.	1-4	1	*i*-Erythrite
4	Tetragonal-pyramidal.....	Pyr.-hemi.	0	1-4	0	Barium-antimony tartrate monohydrate.
5	Scalenohedral.....	Sphenoidal	2 vert.	1-2,2-2	0	Urea
6	Trapezohedral.....	Trapezohedral.	0	1-4,4-2	0	Guanidine carbonate
7	Bisphenoidal.....	Tetartohedral.	0	1-2	0	(No representative known).

Classes 4, 6, and probably 7 rotate the plane of polarized light, indicating the presence of some asymmetrical arrangement of atoms, and their refraction and axial ratios are therefore likely to show poor agreement. In class 5 the positions of the horizontal axes are fixed by the symmetry, so good agreement between the two ratios is possible in the crystals belonging to it. In classes 1, 2, and 3, however, there is a choice between the two sets of horizontal axes, and there is no fundamental reason why the closeness of packing in the layers, which is apparently what determines the refractive effect exhibited all the way around a uniaxial crystal, should be greater in one of these directions than

in the other. Though often greatest in the layers perpendicular to the one selected as a,—calling the most prominent pyramid (111),— it may be greatest in those along the alternate one, a', which is obtained by making this pyramid (101), the relation between the two being: $a' = a\sqrt{2}$; or, if the structure is so simple that the arrangement is about the same in the layers of atoms traversed in both directions, the refractive effect may even be the mean of those along the two axes, and a hypothetical value $a'' = \frac{a + a'}{2}$ must be used.

In the course of the preparation of this paper many helpful suggestions have been received from Dr. H. E. Merwin, of the Geophysical Laboratory, Dr. E. Q. Adams, of the Bureau of Chemistry, and others, to all of whom the writer's warmest thanks are herewith extended.

REFRACTION RELATIONS OF ORGANIC COMPOUNDS

Urea

$CO(NH_2)_2$ Tetragonal-scalenohedral; $a : c = 1 : 0.833$

The simplest organic compound known to crystallize tetragonal is urea, or carbamide; it was accordingly selected as the first subject for study. The refractive indices of this substance

TABLE 3

REFRACTION RELATIONS OF UREA

REFRACTIVE INDICES		REFRACTION RATIO	AXIAL RATIO
ω	ϵ	R_ω/R_ϵ	c/a
1.484 ±0.002	1.602 ±0.002	0.834	0.833

Refractivity, based on mean $n_D = \sqrt[3]{\omega^2\epsilon} = 1.522$ and $\rho = 1.33$: $M_D = 13.77$.
Refractivity, calculated from data obtained from liquids: $M_D = 13.67$.

were determined by the immersion method by using essential oils, in which it is but slightly soluble. The results are shown in table 3, which includes (1) the refractive indices for D, and their probable errors; (2) the ratio of the refractions, R, in the horizontal and vertical directions a and c, that is, $\frac{\omega^2 - 1}{\omega^2 + 2} \Big/ \frac{\epsilon^2 - 1}{\epsilon^2 + 2}$;

and (3) the axial ratio of the substance. The two ratios are always used in the opposite order; that is, if the one refers to a/c, the other is taken as c/a.

The agreement of the two ratios is very exact, and indicates that in urea the standard axial ratio is identical with the true one, all of the atoms having a part in determining the position of the unit sphenoid.

The information at hand now seems sufficient to warrant the working out of the probable space-lattice of the substance, which may be accomplished by bearing in mind the following points:

Since no change from one isomer into another is ever caused by crystallization, molecules must be preserved in crystallized organic compounds better than in most of the inorganic ones that have been studied with X-rays. The chemical molecule should therefore be retained as far as possible. It should be spread out in one plane, somewhat like this: $\begin{matrix} H \\ H \end{matrix} N \overset{O}{C} N \begin{matrix} H \\ H \end{matrix}$ and partial interpenetration of these groups is likely to occur.

Since urea shows cleavage in three directions at right angles, the lattice should have a general cubic plan. But since the crystal class is scalenohedral, there must be some alternation of groupings, corresponding to that shown by the sulfur atoms in the tetrahedral mineral sphalerite. The lattice should possess a vertical axis of alternating four-fold symmetry, two horizontal axes of two-fold symmetry, and two symmetry planes. The atoms must be equally represented in the layers in all three directions in space, and the average distance between their planes vertically be 0.833 times that horizontally. Some explanation of this difference in spacing should be seen in the atomic arrangement.

A space-lattice fulfilling these requirements proves to be very easy to construct; and a portion of it containing five layers of atoms in each direction is shown in figure 1. Four chemical molecules are represented in this cell, as may be seen when it is remembered that of each atom lying on outer surfaces only half belongs to it. The oxygen atoms in the top and bottom layers

may be regarded as belonging alternately to carbon atoms shown, and to others lying in adjacent cells; interlocking thus occurs in these oxygen layers. It also occurs in the nitrogen layers shown, and in both cases is probably associated with residual affinity or secondary valence of these elements.

In the writer's opinion the valency-volume hypothesis, according to which the volumes of atoms are proportional to their valences, which is much used in the study of molecular structure, is

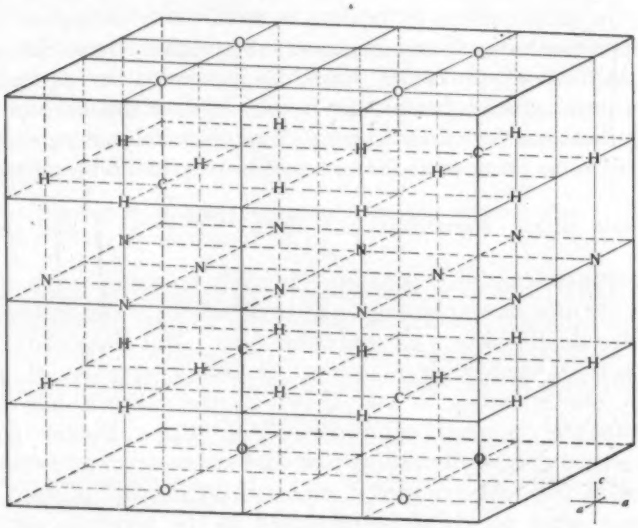

Fig. 1. Space-lattice of urea.

fallacious. Kopp's data on atomic volumes in the liquid state yield the diameters: H, 2.20; O′, 2.45; C, 2.75; O″, 2.85; N, 2.95; or, if the diameter of the H atom is taken as 1.25×10^{-8} cm., those of the others are O′, 1.40; C, 1.55; O″, 1.60; and N, 1.70, all $\times 10^{-8}$ cm. There is no reason to expect marked changes from these values in solids.

In the two horizontal directions, front-back and right-left—which are of course equivalent, as required by the symmetry—

oxygen or nitrogen atoms are present in all the layers and the planes of the layers are therefore regarded as approximately equally spaced. In the vertical direction, however, there are layers containing hydrogen + carbon atoms, alternating with others made up of oxygen and of nitrogen alone. In the first kind the carbon atoms lie over vacant spaces in adjoining layers, into which they can extend, so that the space occupied by these layers is determined by the hydrogen atoms, which are distinctly less in diameter than any of the others. The reason that urea has a negative axial ratio is thus evidently the presence of layers containing hydrogen atoms alternating with others made up of thicker nitrogen and oxygen atoms in the vertical direction, while all the layers contain the latter atoms in the horizontal one.

The next step is to calculate the spacing of the planes in centimeters, which may be done by the formula $d_a = \sqrt[3]{\frac{x \times W \times m}{y \times \rho \times c}}$ where d_a is the distance between the planes in the horizontal direction, x the number of chemical molecules in the portion of the space-lattice studied, W the molecular weight referred to hydrogen, m the mass of an atom of hydrogen, y the number of unit cells in the larger one, ρ the density, and c the vertical crystal axial value. In the case of urea the values are: $x = 4$, $W = 59.57$, $m = 1.64 \times 10^{-24}$ gram, $y = 64$, ρ averages 1.33, and $c = 0.833$. Substituting, $d_a = 1.77 \times 10^{-8}$ cm., which is very slightly greater than the average diameter of the atoms concerned, in liquids. Correspondingly, $d_c = c \times d_a = 1.47 \times 10^{-8}$ cm. In the cell figured there are vertically 1 N layer, 2 H layers, and 2 half O layers; the total $d = 4 \times 1.47 = 5.88 \times 10^{-8}$ cm. If the vertical thickness of an O layer is 2 per cent greater than in liquids, or 1.63, and of N 1.73, total 3.36, the thickness of an H layer $= \frac{5.88 - 3.36}{2} = 1.26$; this barely exceeds the diameter of a hydrogen atom adopted above. The structure assigned to urea thus agrees quantitatively with all available data.

ANTHROPOLOGY.—*Anthropology as a corrective of provincialism.* JOHN R. SWANTON, Bureau of Ethnology.

Anthropology is distinctly the study of man in society. It is by its attention to the group or social idea that physical anthropology differs from anatomy and physiology, comparative philology from the mere study of vocal expression, and culture history from psychology. And it is apparent that the well being of the individual depends, always and in an ever increasing degree, upon the well being of the group of which he forms a part and the harmonious relations between himself and that particular group. Of course anthropology is not the only science which considers man primarily as a social being. The same is true of history, sociology, economics, and various others. But history, at least that of the older orthodox type, limits itself for the most part to those peoples and those periods of which there are scriptorial records, sociology places its emphasis on mankind in the so-called civilized nations, and economics and similar sciences consider man with particular reference to his material environment or else some special phase of his social relations. In particular it is to be observed that each of these sciences is concerned with the peoples of that one great culture center, which, beginning in the immediate neighborhood of the eastern Mediterranean, gradually spread westward until it came to be represented by the so-called civilized nations of today. Anthropology, considering ethnology and ethnography as subordinate branches, is the only science which, professedly and from the very beginning, has taken cognizance of all human societies whether they be conventionally called "civilized" or "uncivilized."

The importance of this fact appears when it is known that what we call civilization has sprung up independently at a number of distinct points or "culture centers," and that no two of these culture centers has consisted of the same elements, has undergone the same institutional or psychical development, has enjoyed, or suffered from, the same environment. Thus the history which each center presents, the expression of its life, the social organizations and institutions which have developed within it are different, and the peculiar outlook on life which an inhabitant of

any one may happen to have needs correction by a study of the outlook of individuals belonging to other centers. Thus in pre-Columbian North America we find that there was a culture center in the eastern woodlands, one on the North Pacific coast, one in the semi-arid Southwest, one, or perhaps, two, in Mexico and Central America, and one in the West Indies. In South America were two or three scattered along the Andean chain and one in the region of Guiana. Turning to the Old World, we are at once arrested by a few well-known culture centers like those of China, India, and the eastern Mediterranean, while centers more obscure may be detected in Polynesia and northeast Africa. On examining some of these we note the further interesting fact that they were originally complex, having resulted from the fusion of several originally independent centers. This is true in a way of the center in the eastern woodlands of North America and those on the Andean plateau, but the most conspicuous example of the kind is to be found in that great east Mediterranean culture center from which our own civilization is descended. This is found to have incorporated a center in the Nile valley, another in the valleys of the Euphrates and Tigris, a third on the island of Crete, and probably a fourth in eastern Asia Minor. These facts show that we must not consider culture centers as so many water-tight—or rather influence-tight—compartments having no meaning for one another. On the contrary it is not likely that a single one could be pointed out which had been affected in no degree by at least one other, and there is reason to believe that there has never been a time when thought vibrations have not been able to reach all parts of the human race, no people that may be said to have been intellectually sterilized. Each of these centers is to be regarded as the result of a particular running-together or complex of thought waves, a systematization of ideas found in their crude and dissociated condition among all human beings, or at least among many more than those constituting the particular center.

At the same time anthropology does not lose sight of or ignore peoples not included in culture centers. Viewed in one way they may be divided up and attached to the several centers as so many

parts of a "culture area," since each center influences the more primitive people by whom it is surrounded, but it would probably be truer to consider these primitive or "savage" peoples as comprising the raw material, the people of dissociated ideas and institutions, out of which the several culture centers have been built, the lowlands of culture from which the centers of civilization project like so many mountain peaks. The subsequent reaction of the culture centers upon them should not obscure the fact of their originally fundamental position.

And now as to the importance of all this for us. We know how, even in the comparatively limited horizon of one nation or one state, individuals tend to assume that to be right and just to which they themselves and their immediate associates are accustomed and that to be wrong which is foreign to their ways of thought. We call such an attitude "provincial," and we laugh at the man from the back township or the mountain county, who thus exhibits his narrow prejudices and the limited mental outlook of the community from which he sprang. But we should be warned that provincialism is relative. One may be "cosmopolitan" as regards counties or towns and make fun of the provincial with only the county or town outlook but be equally provincial himself with relation to views entertained in the next state. Again he may be cosmopolitan as between states but provincial when it comes to another nation, or cosmopolitan as between nations of approximately the same type of civilization but provincial when confronted with nations or peoples of a different cultural or racial type. Even the broadest of us is prone to consider, or rather assume—for such things are often imbedded too deeply in our subconscious natures to be made matters of consideration—that certain ideas, customs, technical processes, forms of government are best, or rather that they are essential, as much part and parcel of humanity as hand or foot or eye, yet we may be absolutely deceiving ourselves. It is the especial function and peculiar privilege of anthropology systematically to study and record ideas, technical processes, customs, and so on wherever found, to the end that mankind may constantly become less provincial, more cosmopolitan in his outlook, may discern

more clearly what are the essential accompaniments of human life and human association, what are its nonessentials, also what institutions have been worked out by different peoples and found of benefit, what have been found harmful, what laws seem to be justified by the experience of mankind in other parts of the world and in other periods. In this way anthropology paves the way for a broader outlook on the questions which every culture center, every people, nay every individual, has to face. It renders available as guides, not merely the experience of our immediate ancestors, of related peoples, of our cultural forebears who happened to be possessed of the art of writing, but the experience and experiments of all peoples without any limit other than that set by the boundaries of the globe or the extent to which human memorials have been preserved.

And in the very processes that this study sets at work there is involved a most important corollary. As the more intelligent of all nations seize upon data provided in this manner the cosmopolitanization of thought is certain to extend until mutual toleration and appreciation take the place of mutual repugnance, dislike, and hostility, and much of the psychology that now ultimates itself in war passes away. An obsession that the good of the world requires that its culture shall be all German, or French, or English, or American is but the display on a wider field of the provincialism which holds that it should be patterned on that of Jones county or Smithville. It is an obsession that the prosecution of anthropological studies and the diffusion of the results of such studies are certain to destroy, and I presume that no reasonable human being will, in the light of current history, consider such destruction of other than practical value.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Ore deposits of the northwestern part of the Garnet Range, Montana.* J. T. PARDEE. U. S. Geological Survey Bulletin 660-F. Pp. 80, with 4 plates and 10 figures. 1918.

The report describes the quartz lodes and placer gravels and the principal features of the physiography and the geology in an area of about 400 square miles north of Clark Fork River and east of Missoula. The lodes are considered by districts, those of the Garnet, Coloma, and Elk Creek districts, which are valuable chiefly for gold, being classified as filled fissures and replacement veins in granodiorite and schist. In the Top o'Deep district there are contact-metamorphic replacements in limestone valuable for copper, and quartz veins that contain gold. In the Copper Cliff district mineralized fault breccias, and in the Clinton district composite veins or shear zones in granodiorite, are valuable for copper. Outlying deposits consist in part of silver-bearing galena that has replaced limestone.

Under placer deposits is given a brief historical sketch of Bear and Elk creeks, which produced between $6,000,000 and $10,000,000 in placer gold in the "early days," and the origin of the gold-bearing gravels is discussed.

Under geology there are condensed descriptions of the rocks, which include 5000 feet of Belt strata, chiefly quartzite and shale; 4000 feet of Paleozoic strata, mostly limestone; early Tertiary or late Cretaceous intrusive granodiorite; and middle Tertiary extrusive rocks. Folds and faults involve the strata, one of the chief structural features being a large overthrust fault that has carried a great mass of Belt rocks from the west over Paleozoic and younger formations.

Under physiography the elevated remnants of a peneplain are described and their correlation with an erosion surface of Eocene age known in the adjacent regions is indicated.

J. T. P.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The 121st meeting of the Academy was held in the Assembly Room of the Cosmos Club the evening of Thursday, February 21, 1918, with President BRIGGS presiding, the occasion being the second lecture of the series on Science in Relation to the War, by Dr. GEORGE E. HALE, Director of the Mt. Wilson Solar Observatory of the Carnegie Institution of Washington, and Chairman of the National Research Council. The subject of the address was *Astronomy and war—some examples of the close parallelism between the methods and work of the astronomer and those of the military engineer.* The lecture, which was abundantly illustrated with lantern slides and moving pictures, was aimed to show that men of science in any field, no matter how remote apparently from that of military affairs, are prepared by the usual demands of their scientific investigations to deal with problems pertaining to the war.

The 122d meeting of the Academy was held in the Assembly Room of the Cosmos Club the evening of Thursday, March 7, 1918, with President BRIGGS presiding. The third lecture of the series on Science in Relation to the War was delivered by Col. C. F. LEE, Commanding Officer, British Aviation Mission, his subject being *Aviation and the war.* The address, which dealt essentially with the more practical phases of aviation work, has been published in this JOURNAL (**8**: 225–232. April 19, 1918). Colonel LEE was followed by Major GILMORE of the Royal British Flying Corps, who spoke appreciatively of the work of American flyers and dwelt upon the necessity of expert training in gunnery, as well as in actual flying, and the personal qualifications which combine to make a successful and resourceful flyer.

The 123d meeting of the Academy was held in the Assembly Room of the Cosmos Club on the evening of Wednesday, April 3, 1918, with President BRIGGS presiding. The occasion was the fourth lecture of the series on Science in Relation to the War, by Maj. Gen. JOHN HEADLAM, C.B., D.S.O., in charge of the British Artillery Mission, entitled *The development of artillery during the war.* A summary of the lecture will appear in a later number of the JOURNAL.

WILLIAM R. MAXON, *Recording Secretary.*

PHILOSOPHICAL SOCIETY OF WASHINGTON

The 802d meeting was held at the Cosmos Club, March 2, 1918. Vice-President HUMPHREYS in the chair; 40 persons present. The minutes of the 801st meeting were read in abstract and approved.

Lieut. D. L. WEBSTER presented a paper on *Emission quanta phenomena in X-rays*, illustrated by lantern slides. The paper was a brief account of the work on this subject that has appeared in the past three years in the *Physical Review* and the *Proceedings of the National Academy of Sciences*.

In the general radiation spectrum, the frequency whose quantum is the energy of one cathode electron was found by Duane and Hunt, and by Hull, to have an upper limit, at which the spectrum ends. It was shown by Webster that the existence of such a limit to the spectrum is direct evidence that the rays are trains of periodic waves rather than pulses; and with further experimental work, that if atoms in the anticathode could be struck only by electrons of a definite velocity, any atom's chance of emitting rays of a given frequency jumps from zero discontinuously to a finite value as the energy of the cathode electron is raised continuously past the quantum value of that frequency. A further continuous increase of energy of the cathode electron would produce a continuous decrease of intensity of rays of that frequency.

For the characteristic rays of the K series, it was found by Webster that no such rays are produced until the cathode electron's energy reaches the quantum value of the highest frequency of the series, at which point all the lines of the series appear together. Their intensities increase by the same law for all lines, but this law is very different from that holding for any given frequency in the general radiation. These phenomena are all consistent with the hypothesis that the primary characteristic rays produced by cathode rays come from the same atomic mechanism as the secondary characteristic rays occurring in fluorescence. This statement holds, whatever that mechanism may be.

For the L series it was found by Webster and Clark that the laws are similar to those of the K series except that the lines must be considered as belonging to at least two, and probably three, separate series, each of which behaves like the K series.

Discussion: This paper was discussed by Messrs. SWANN, WHITE, and FOOTE.

The second paper, on *Determination of the constant C_2 of Planck's law*, was presented by Major C. E. MENDENHALL. It was illustrated by lantern slides. No abstract furnished. A paper of the same title was published in the *Physical Review*, **15**: 515. November, 1917.

Discussion: This paper was discussed by Messrs. CRITTENDEN, ABBOTT, COBLENTZ, FOOTE, SOSMAN, WHITE, SWANN, and WEBSTER.

H. L. CURTIS, *Recording Secretary.*

The 803d meeting was held at the Cosmos Club, March 16, 1918. President BURGESS in the chair; 39 persons present. The minutes of the 802d meeting were read in abstract and approved.

A paper on *Thermal expansion of alpha and of beta brass* by P. D. MERICA and L. W. SCHAD was presented by Mr. Merica. This paper was illustrated by lantern slides. Within the past four years an investigation has been in progress at the Bureau of Standards of the cracking or fracturing of cast and wrought brass, particularly of the type composition, 60 per cent of copper and 40 per cent of zinc. It has been found that in most failures of such brasses in service the cracking can be ascribed to the presence of initial stresses in conjunction with surface corrosion. These initial stresses may be produced either in the mechanical working of the material, such as drawing or rolling or by shrinkage, as in the case of cast metal. As, however, a number of instances of cracking in brass of this type have come to the attention of the authors for which such explanations cannot be applicable, it was their intention to ascertain whether local internal stresses could not be produced in brass of this composition by heat treatment such as it might receive in manufacture.

Brasses of this type are heterogeneous, consisting of the mechanical mixture of two constituents, called respectively, the alpha and the beta constituents. Measurements of the linear thermal expansion of these two constituents have shown that of the beta constitutent to be considerably in excess of that of the alpha. So great is this difference that rough calculations have shown the possibility of the development of average stresses due to the sudden cooling by quenching of the brass containing these constituents equal to approximately 15,000 pounds per square inch.

Experiments showed that these stresses were probably responsible for the lowering of the proportional limit of such brasses amounting to as much as .25 per cent.

The thermal expansion curves illustrate also very well the nature of the thermal transformations in the beta constituent varying about 1460°C.

Discussion: This paper was discussed by Messrs. WHITE, BRIGGS, and BURGESS.

A paper on *The principles of electrical measurements at radio frequencies* was presented by Mr. J. H. DELLINGER. The principles of radio or high-frequency measurements are coextensive with the principles of radio engineering to an extent not true in other fields. This is typified in the wavemeter, which is a complete radio transmitting and receiving station, albeit in miniature. The principles of ordinary alternating current theory apply with little change to the phenomena at very high frequencies. This was not true a few years ago, when damped waves were universally used in radio work, but the introduction of satisfactory sources of undamped currents has largely eliminated the specialized theory that went with damped waves.

While precision measurements with direct current are commonly made by null methods, high-frequency measurements on the other hand use the opposite critical phenomenon, a maximum rather than minimum of current. Resonance or tuning is thus the basis of radio measurements as well as of wave transmission and reception. At resonance the reactances due to capacity and to inductance annul each other and the current is limited by resistance only. As resistances are small in comparison with reactances at radio frequencies, the current is relatively very great at resonance, i.e., the resonance is very sharp and is thus a suitable basis for measurements.

The wavemeter is a resonance instrument, and is used to measure capacity and inductance as well as wave length. The other most generally useful radio instrument is the ammeter. With these two, measurements are made of current, resistance, power, and associated quantities, in addition to the quantities above mentioned. In general the best methods are those which are the least complicated. This is particularly true because of the disturbing effects of small inductances and capacities in lead wires and accessory apparatus. Small capacities in and near the measuring circuits are especially troublesome. They include the capacities of instrument cases, table tops, walls, and the observer, and they cannot always be determined or eliminated.

While resistance is of distinctly less importance in determining the flow of currents at high frequencies than at low, nevertheless resistance is the measure of power consumption. As it varies rapidly with ratio frequencies, its measurement is very necessary. The same measurement gives resistance and the associated quantities, sharpness of resonance, phase difference, and decrement.

Great advances in the precision of all these measurements have recently been made possible by the introduction of electron tubes as sources of current. They have the very great advantage of giving a steady current, and as the current is undamped the simple sine wave theory of alternating currents may be used.

Discussion: The paper was discussed by Messrs. WHITE, BICHOWSKY, and SWANN.

Mr. G. W. VINAL then gave a paper on *Some electrical properties of silver sulphide.* Silver sulphide may be prepared in the form of short wires or thin strips like a metal. The wire, which must be drawn hot, has been found to conduct electricity like a metal of high specific resistance and practically zero temperature coefficient. The strip of sulphide, rolled at room temperature, has a large temperature coefficient and shows both metallic and electrolytic conduction at the same time. It has a volt-ampere curve characteristic of a pyroelectric conductor. The resistance of these strips has been examined with both alternating and direct current, with the result that the alternating-current resistance was nearly always found to be higher than that with the direct current, and the passage of a small alternating current of a frequency as low as 60 cycles increased temporarily the resistance of the sulphide, while a small direct current produced the opposite effect.

Experiments were made to find the electrochemical decomposition due to the electrolytic conduction of the strips of sulphide. A strip in air (5.5 by 0.3 by 0.01 cm.) with silver-plated ends was soldered to copper leads and put in a direct-current circuit. The initial current of 25 milliamperes was passed through it for nearly an hour without visible change. The current was increased by steps of 50 milliamperes at 10-minute intervals until with 200 milliamperes a discoloration of the plating at the anode end was noticed. . A further increase to 300 milliamperes completed the destruction of the silver plating at the anode end and finally burned off the terminal, but before this happened a myriad of little shiny silver crystals appeared on the black surface of the sulphide. The appearance of these crystals was carefully studied under the microscope, and it was found that they occurred even to within a small fraction of a millimeter of the anode terminal. They appeared in various forms, some of which suggested that they had been expelled from the interior of the sulphide by considerable force.

Discussion: The paper was discussed by Messrs. BUCKINGHAM, HONAMAN, BICHOWSKY, SOSMAN, and BURGESS.

E. C. CRITTENDEN, *Corresponding Secretary.*

BOTANICAL SOCIETY OF WASHINGTON

The 128th regular meeting of the Society was held at the Cosmos Club at 8.00 p.m., Tuesday, April 2, 1918. There were 28 members and 4 guests present. Messrs. L. L. C. KRIEGER, H. F. BERGMAN, G. A. MECKSTROTH, and WM. N. ANKENEY were elected to membership. The following scientific program was given:

CARLETON R. BALL: *The grain sorghums: a botanical grouping of varieties cultivated in the United States* (with lantern). There are two chief centers of origin for the sorghums, Africa and India. The principal groups cultivated in the United States are kafir, milo (including feterita), and durra. All of these are of African origin. The kafir varieties mostly were obtained from the native tribes in Natal, South Africa. The Guinea kafir, however, probably was derived from the West Coast of Africa, whence it was brought as food for slaves during their long voyage to America. It is now cultivated in several islands of the West Indies. The milo varieties probably are of Egyptian origin. Very similar forms are grown in Egypt today under the names Durra Beda (white), Durra Safra (yellow), and Durra Ahmar (brown). Feterita was derived from the British Egyptian Sudan. The durra varieties, white and brown, probably came from North Africa, where they are still found among the native tribes. These are the varieties known in California as "White Egyptian corn" and "Brown Egyptian corn," respectively. The white variety has been grown in the Great Plains area under the name "Jerusalem corn." The kaoliang varieties are derived from North China and Manchuria. The different groups are clearly separated by botanical characters. The speaker exhibited charts showing by means of keys the classification of the sorghums.

The chief groups of the sorghums are Broomcorn, Sorgo, Kaoliang, Kafir, Shallu, Durra, and Milo. Keys were given showing the relation of the varieties of the Kafir group and of the Durra-Milo group.

F. V. RAND: *The Shaw aquatic gardens* (with lantern). The Shaw Aquatic Gardens, near Washington, were started several years ago as a matter of curiosity and recreation. Beginning with a half-dozen roots of the native white waterlily set in a little dug-out pond in the swamps of the Anacostia River the gardens have increased in size until there are over five acres under water. In these ponds are grown nearly all varieties of water plants that will live in our climate. They are sold all over the United States and even in the Hawaiian Islands. The business has been an artistic and financial success from the start; but has not been without its difficulties. Turtles, muskrats, and various insects offer each their special brand of tribulation. The biology and successful control of a serious fungus disease of pond lilies (caused by *Helicosporium nymphaearum* n. sp.) have been worked out by the writer; and a fungous leaf spot of Egyptian lotus (caused by an *Alternaria*) is under study.

Following Mr. Rand's paper, Mrs. FOWLER, the Manager of the Shaw Gardens, invited the members of the Society to visit the gardens and pointed out that June is one of the best times to inspect them.

H. N. VINALL, *Corresponding Secretary.*

BIOLOGICAL SOCIETY OF WASHINGTON

The 581st regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, March 9, 1918; called to order at 8 p.m. by President ROSE; 30 persons present.

On recommendation of the Council Miss E. E. STEVENSON was elected to membership.

Two informal communications were presented:

T. S. PALMER made remarks on the systematic feeding of quail in the city of Washington during the past winter. A census of these birds showed 60 coveys with a total of 1235 individuals. Discussed by Gen. T. E. WILCOX.

R. W. SHUFELDT showed lantern slide X-ray picture of the double-headed tortoise exhibited at the previous meeting of the Society. Major Shufeldt also exhibited two living specimens of the whip-tailed scorpion, *Thelyphonus giganteus*, collected by Mr. Nelson R. Wood, at Auburndale, Florida. Reference was made to its geographic distribution, Florida and West Indies, its habits in capitivity, its structure, and its systematic position. Its popular names were stated to be vinegerone, vinaigner, mulekiller, and vinegar maker.

The regular program consisted of three communications:

JOHN T. ZIMMER: *An intensive feeding habit in young herons.* Read by the Recording Secretary in the author's absence in New Guinea. This note will appear in full in the Proceedings of the Society. It was discussed by Dr. T. S. PALMER and ALEX. WETMORE.

E. P. CHURCHILL, JR.: *The life history of the blue crab.* Various features of the life history of this form were studied by means of observations and experiments carried on during the interval from July 1, 1916, to December 1, 1917, especial attention being given to the crab of Chesapeake Bay. The eggs of the crab were found to measure about 1/100 of an inch in diameter. As they are laid they become attached to the endopodites of the four anterior pairs of swimmerets, forming the "sponge." About 1,750,000 eggs are laid at one time. They remain upon the swimmerets until they hatch, which event occurs within about fifteen days after they are laid. Upon hatching the young leave the female at once and do not cling to her as has often been supposed. Most of the spawning in Chesapeake Bay is accomplished from the first of June to the first of August and occurs mostly in the southern part of the bay.

About one month is required in which to pass the zoeal and the megalops stages. After the latter stage is passed the crab molts about fifteen times before the adult condition is reached. Most probably it does not molt after reaching maturity. The young, which are hatched in the southern part of the bay, migrate to Maryland waters and reach maturity and mate there. There is a cessation of growth and molting during the winter. Maturity is reached during the second summer, at the age of about twelve to fourteen months. Mating occurs during July and August. Mating takes place in the female at the time of her last molting, at which time the abdomen changes from a triangular to a broad rounded form. Most of the females do not lay the eggs the same season in which mating occurs but migrate to the southern part of the bay, lie on the bottom in deep water there, and spawn the following season. The males do not migrate southward to as great an extent as do the females, but remain in more northerly waters. The crabs do not bury in the substratum during the winter as has been commonly supposed.

At least two and probably three batches of eggs are laid by the females. Some lay their first lot late in the summer and another lot the next season. Some lay two batches during the same summer. At the time of the only copulation which occurs during the life of the female, enough spermatozoa are deposited by the male in the sperm sacs of the female to fertilize all the eggs which she lays during her life time. The females die shortly after the last batch of eggs is laid, death usually occurring during the late summer or early fall. The usual length of life of the crab is about three years.

The paper was illustrated by lantern slides. It was discussed by W. P. HAY and Dr. T. S. PALMER.

R. H. TRUE: *Notes on the early history of the pecan in America.* The earliest account of the pecan is probably that by Cabeza de Vaca, who saw it in 1533 on the lower course of the Guadaloupe River in Texas. De Soto found it in use by the Indians in 1540–42 along the Mississippi River from near the mouth of the Illinois River and southward. The pecan seems to have been first introduced into the English

colonies by Captain Bouquet and John Bartram in September 1761. Daniel Clark of New Orleans sent nuts to Vice President Jefferson in 1799. The first botanical description is by Jefferson in his *Notes on Virginia*, in 1782. The name "pecan" was found in use by De Soto about 1540 and by Pénicault, 1704, among the tribes of the Mississippi Valley; probably not used by the Texas tribes west of this region. The pecan was probably cultivated in Spain at an early date, but the first ascertained record of its introduction into Europe was by John Bartram who sent pecans to Peter Collinson in England early in 1761. First introduction into France was probably through Jefferson in 1787. The earliest cultivation in America probably took place in Mexico about 200 years ago. William Prince succeeded on Long Island with nuts planted in 1772. Abner Landrum successfully budded the pecan on common hickory at Edgefield, S. C., in 1822.

The paper was discussed by Gen. T. E. WILCOX and Major R. W. SHUFELDT.

The 582d regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, March 23, 1918; called to order at 8 p.m. by President ROSE; 65 persons present.

The regular program consisted of an illustrated lecture by EDMUND HELLER entitled *The Chinese borderland of Tibet and Burma*. Mr. Heller gave an account of his recent collecting trip made in conjunction with Mr. Roy Andrews through Japan, China, and northern Burma. He described the route taken, the geographic and geologic features of the country passed through, the characteristics and customs of the people, and the nature of the larger animals encountered. He called particular attention to the deforested conditions of China and the intensive system of agriculture in vogue. The absence of animal life in China was rather conspicuous as contrasted with many of the neighboring and less densely populated countries. The scarcity of birds in some places with no apparent increase in insect pests was noteworthy. His talk was profusely illustrated by lantern slide views of all the features mentioned by him.

Mr. Heller's paper was discussed by the chair, A. S. HITCHCOCK, and Dr. GEORGE W. FIELD.

M. W. LYON, JR., *Recording Secretary*.

ENTOMOLOGICAL SOCIETY OF WASHINGTON

The 312th regular meeting of the Society was held at the Cosmos Club, April 4, 1918. There were twenty-nine members and four visitors present.

In the absence of President E. R. SASSCER, the Honorary President Mr. E. A. SCHWARZ occupied the chair.

The following names were favorably acted upon for membership: Dr. J. A. NELSON, Bureau of Entomology; Mr. OSCAR H. BASSECHES, Bureau of Entomology; Mr. L. P. ROCKWOOD, Forest Grove, Oregon;

Mr. C. W. COLLINS, Gipsy Moth Laboratory, Melrose Highlands, Massachusetts; and Mr. HOWARD L. CLARK, North Farm, Bristol, Rhode Island.

The regular program was as follows:

HAROLD MORRISON: *Notes on the Virgin Islands.* Mr. Morrison discussed briefly the size, location, past history, and the economic development of the islands, giving some notes on the principal agricultural crops and their chief insect enemies. Among the insects mentioned were termites, the different varieties of a species of weevil (*Diaprepes* sp.) the cotton-leaf blister mite, and the sweet-potato weevil (*Euscepes batata*). About thirty species of scale insects were collected, and about twenty-six hundred specimens representing other orders. No fruit flies were found, and fruit was very scarce on the islands due to the great destruction caused by the recent hurricane. Mr. Morrison's communication was discussed by Messrs. SCHWARZ, CASEY, BUSCK, and PIERCE.

R. E. SNODGRASS: *The value of pictorial charts in extension entomology.* This paper was illustrated by a number of artistically drawn charts designed to illustrate the life histories of economic insects. The speaker presented a strong argument in favor of this manner of carrying entomological information to the general public. He stated that the charts would attract and hold attention, that they were designed to bring out the most vulnerable points in the life-histories of the insects illustrated; and that they were quickly and easily read. He believed that the essential points in control would be more readily grasped by the reader than from the written page. In discussing Mr. Snodgrass' remarks Dr. L. O. HOWARD pointed out some of the excellencies of the charts from the artistic standpoint.

W. D. PIERCE: *The case of the genera Rhina and Magdalis.* Read by title.

E. A. MCGREGOR: *A new host plant for the cotton-boll weevil.* Read by title.

S. A. ROHWER: *New sawflies of the subfamily Diprioninae.* Read by title.

A. B. GAHAN, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. H. FOSTER BAIN has recently returned from China, and has accepted the position of Assistant Director of the Bureau of Mines.

Dr. GRAHAM EDGAR, of Throop College, Pasadena, California, has been appointed Technical Assistant to the newly established Research Information Committee, and has entered upon his duties at the office of the National Research Council. Mr. WALTER M. GILBERT, of the Carnegie Institution of Washington, is secretary of the local office of the Committee.

Dr. YOGORO KATO, formerly a member of the Research Laboratory of Physical Chemistry at the Massachusetts Institute of Technology, and now professor in the Higher Technical School of Toyko and director of the Nakamura Chemical Research Institute, visited Washington in March.

Dr. E. C. LATHROP, formerly of the Laboratory of Soil Fertility Investigations, left Washington on May 1, 1918, to accept a position in the organic dye research laboratory of E. I. du Pont de Nemours and Co., at Wilmington, Delaware.

Mr. JOSEPH U. MONROE, chief of the telegraph division of the Weather Bureau, died suddenly on April 13, 1918, after a service with the Bureau of twenty-seven years' duration.

A "Joint Information Board on Minerals and Derivatives" has been formed for the purpose of systematizing the handling of official inquiries regarding minerals and mineral products. This body is intended to serve as a clearing house to secure the prompt preparation and transmittal of data from a single authoritative source without duplication of effort, and is composed of representatives from the various government bureaus, boards, and departments interested. Mr. POPE YEATMAN, of the War Industries Board, Division of Raw Materials, is chairman, and Dr. EDSON S. BASTIN, of the Geological Survey, is secretary of the new Board.

The following persons have become members of the ACADEMY since the last issue of the JOURNAL:

Mr. SIDNEY F. BLAKE, Bureau of Plant Industry, Department of Agriculture, Washington, D. C.

Dr. JOSEPH AUGUSTINE CUSHMAN, Sharon, Massachusetts.

Mr. ERNEST G. FISCHER, U. S. Coast and Geodetic Survey, Washington, D. C.

Professor WILLIAM SUDDARDS FRANKLIN, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Mr. NED HOLLISTER, National Zoological Park, Washington, D. C.

Dr. RAYMOND PEARL, U. S. Food Administration, Washington, D. C.

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